RESIDUAL ACTIVITY OF SEVERAL NEW INSECTICIDES TO ADULT *ANOPHELES QUADRIMACULATUS* IN ADOBE-LINED EXPERIMENTAL HUTS[1]

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Experimental huts have been used to assess the residual effectiveness of insecticidal deposits to anopheline mosquitoes ever since DDT treatment of homes was shown to interrupt malaria transmission. Although changes have been made in the design of the huts and in the construction materials used, the objective of the studies remains the same, namely, to find pesticides other than DDT that will retain their effectiveness against mosquitoes for extended periods when used to treat the interior of homes.

The present paper gives results obtained in tests with female *Anopheles quadrimaculatus* exposed to residues of 10 compounds in the experimental huts at Savannah, Georgia.

METHODS. The experimental huts were constructed of plywood on a 6 x 6-foot base, and with a 6-foot wall at the back, and a 7-foot wall at the front. Adobe blocks (12 x 17 x 2 inches), from compressed local clay, were used to line the inner walls of the huts. The doors and ceiling were plywood. Each hut had a 2 x 2-foot window located in the center of the east wall fitted with a cone-shaped wire frame that extended into a trap on the outside. The frame was covered with plastic sheeting and had an opening of 1½ inches at the apex. Near the center of the back wall was an opening 1½ inches wide x 6 inches high, through which mosquitoes could enter the hut from a cage attached to the wall on the outside. Extending across the front and back walls of the hut just below the ceiling was a 2-inch screened opening.

All insecticides were applied as suspensions. Treatments were made at 40 psi with a conventional hand sprayer equipped with an 8002 nozzle. After the huts had been treated the floors were relined with clean paper. Table 1 gives the compounds used, and their chemical composition.

Treatments were evaluated by: (1) confining mosquitoes so that they would contact the treated adobe or wood surfaces; (2) exposing free-flying mosquitoes either by release within the hut or by allowing them to enter the hut through the opening in the back wall; and (3) suspending caged mosquitoes near the center of the hut.

Evaluation of residues on adobe and wood surfaces was made by exposing dieldrin-resistant *A. quadrimaculatus* females to treated surfaces for 1 hour beneath plastic cones at weekly intervals. Three replicates were made on each surface with 10 females per cone. After exposure, the specimens were held for 24-hour mortality determination.

For 3 to 5 weeks after the huts were treated, mosquitoes were released into them by attaching a carton of specimens to the outside of the back wall over the opening at 4:00 p.m. The carton remained in place until 8:00 a.m. the following morning. A caged rabbit was placed in the hut to serve as an attractant. After the exposure period, the mosquitoes in the hut were collected, the window trap was examined, and the number remaining in the entrance cage was recorded. Any living mosquitoes were held for 24-hour mortality determination. However, in later tests, 60 female mosquitoes were released directly in the hut and ex-

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TABLE 1.—Chemical composition of toxicants [1] used.

Compound	Chemical composition
Baygon [2]	o–isopropoxyphenyl–N–methylcarbamate
Bromophos [3]	0, o–dimethyl o–(2, 5–dichloro–4–bromophenyl) thionophosphate
Carbamult [4]	3–methyl–5–isopropylphenyl–N–methylcarbamate
Dursban [5]	0, o–diethyl o–(3, 5, 6–trichloro–2–pyridyl) phosphorothioate
EPN [6]	o–ethyl o–p–nitrophenyl phenylphosphonothioate
GC–9879 [7]	alpha (diethoxyphosphinothioylthio) gamma–butyrolactone
H–9485 [8]	2–alloxyphenyl N–methylcarbamate
Landrin [9]	3, 4, 5–trimethylphenyl methylcarbamate
Mobam [10]	4–benzothienyl-N-methyl carbamate
SD–8280 [9]	2–chloro–1–(2, 4–dichlorophenyl) vinyl dimethylphosphate

[1] Use of trade names is for identification purposes only and does not constitute endorsement by the Public Health Service or the U. S. Department of Health, Education, and Welfare.
[2] Chemagro Corporation, Kansas City, Missouri.
[3] Cela Chemical Company, Ingelheim/Rhein, West Germany.
[4] Schering AG, Halchtersche Strase 33, West Germany.
[5] The Dow Chemical Company, Midland, Michigan.
[6] E. I. duPont de NeMours, Wilmington, Delaware.
[7] Allied Chemical Corporation, General Chemical Division, Morristown, New Jersey.
[8] Hercules Powder Company, Wilmington, Delaware.
[9] Shell Development Company, Modesto, California.
[10] Mobil Chemical Company, Metuchen, New Jersey.

posed for 2 or 4 hours. Two-hour exposure was used against each batch of mosquitoes until mortality fell below 90 percent, after which it was increased to 4 hours. The mosquitoes were then collected as described previously and held for 24-hour mortality determination.

Caged mosquitoes (25 females) were suspended for 2 or 4 hours near the center of the hut to determine possible fumigant action of the treatment.

The three types of tests were duplicated in an untreated hut.

RESULTS. Table 2 gives results of 60-minute exposure of female mosquitoes to surfaces treated with candidate compounds. Dursban was the most effective material on adobe surfaces, giving greater than 90 percent mortality for 16 weeks. Baygon and Landrin followed with 7 and 5 weeks, respectively, of 90 percent or greater kills. Bromophos gave erratic results on adobe after the first week but had kills greater than 90 percent in 8 of the 20 weeks tested and above 70 percent in 15 of the 20 weeks. Mobam, EPN, Carbamult, GC–9879, SD–8280, and H–9485 did not give 90 percent kills for more than 2 weeks.

On wood surfaces, Dursban, Baygon, bromophos, and Hercules 9485 were still giving kills greater than 90 percent at termination of tests. Only Mobam and EPN failed to give at least 12 weeks of 90 percent or greater kills.

In the tests in which mosquitoes entered huts through an opening in the back wall, all compounds except EPN and GC–9879

TABLE 2.—Results of wall cage tests on adobe and wood surfaces when dieldrin-resistant *Anopheles quadrimaculatus* were exposed to residues of indicated compounds for 60 minutes.

Compound	Dosage g/m²	No. of weeks with 90 percent or greater mortality	
		Adobe	Wood
Baygon	2	7	>20
Bromophos	2	1	>20
Carbamult	1	0	18
Dursban	2	16	>18
EPN	0.5	0	0
GC-9879	2	0	12
H-9485	2	2	>15
Landrin	2	5	15
Mobam	2	1	0
SD-8280	1	0	13

gave kills greater than 90 percent for the 3- to 5-week test period. As tests with caged mosquitoes indicated that some compounds were producing sufficient vapor to kill mosquitoes, exposure periods were reduced to minimize this vapor action. The exposure was for 2 hours until the mortality fell below 90 percent, when it was increased to 4 hours. Table 3 gives

TABLE 3.—Number of weeks indicated compounds gave 90 percent or greater mortality of dieldrin resistant *Anopheles quadrimaculatus* released in treated experimental huts for 2 or 4 hours.

Compound	Dosage g/m²	Hours exposure 2	4
Baygon	2	>20	..
Bromophos	2	>20	..
Carbamult	1	9	>20
Dursban	2	>18	..
EPN	0.5	[a]	[b]
GC-9879	2	[c]	[d]
H-9485	2	>15	..
Landrin	2	12	>18
Mobam	2	6	17
SD-8280	1	[c]	5

[a] Mortality below 90 percent when first tested on week 6.
[b] Mortality below 90 percent when first tested on week 7.
[c] Mortality below 90 percent when first tested on week 4.
[d] Mortality below 90 percent when first tested on week 5.

results obtained with 2- and 4-hour exposure periods. With a 2-hour exposure, Baygon, bromophos, Dursban, and Hercules 9485 gave kills greater than 90 percent of released mosquitoes for the test period (20, 20, 18, and 15 weeks, respectively). The next most effective materials were Landrin, Carbamult, and Mobam. EPN, GC-9879, and SD-8280 gave mortalities of less than 90 percent when first tested. With a 4-hour exposure, Mobam, SD-8280, and Carbamult gave 17, 5, and 20 weeks, respectively, of 90 percent or greater kills, but EPN and GC-9879 failed to reach the 90 percent mortality level.

In tests with caged mosquitoes suspended near the center of the huts, Dursban and Baygon gave complete kills for 18 and 20 weeks, respectively, with a 2-hour exposure. Hercules 9485 and Landrin gave from 97 to 100 percent mortality for 14 weeks with a 2-hour exposure. With a 4-hour exposure Landrin gave complete kills through week 17. Carbamult gave 97 to 100 percent mortalities with a 2-hour exposure for 11 weeks, and with a 4-hour exposure 88 to 100 percent kills for weeks 12 through 18. At the 2-hour exposure period, bromophos gave erratic results. Mosquitoes exposed to SD-8280, GC-9879, Mobam and EPN for 2 or 4 hours provided low kills. Baygon, bromophos, Dursban and Hercules 9485 were not included in the 4-hour exposure tests, since mortalities of free-flying mosquitoes in huts treated with these materials remained above the 90 percent level for duration of tests.

Results from the three types of tests (cone, released and caged) indicate that Dursban was the most effective material followed by Baygon, Landrin, and bromophos. The high kills obtained from the vapor of some of the compounds were unexpected and adds to the complexity of conducting hut tests. An illustration of difficulties involved in evaluation is shown by results obtained from huts treated with Carbamult and SD-8280. Neither material was effective in cone tests on adobe surfaces but gave 18 and 13 weeks, respectively, of 90 percent kills on wood surfaces. With mosquitoes in suspended cages, Carbamult gave 97–100 percent kills for 11 weeks, and SD-8280 was ineffective when first tested. This would indicate that Carbamult was quite active as a vapor. With free-flying mosquitoes, Carbamult gave 90 percent kills for 9 weeks, and SD-8280 was ineffective when first tested on week 4. This could indicate that mosquitoes in the hut treated with Carbamult were being killed by contact with residues on wood or by vapor from the material. This also raises the question as to which treated

surface produces the vapor, adobe or wood. If vapor is the main killing agent in the hut treated with Carbamult, an increase in exchange of air would greatly change the mortality obtained with free-flying mosquitoes. This could be true with any material that has a high vapor action.

SUMMARY. Ten compounds as suspensions were evaluated as residual deposits in mud-walled experimental huts at Savannah, Georgia, against dieldrin-resistant *A. quadrimaculatus* females. Dursban was the most effective material on adobe surfaces, as determined by wall cage bioassay tests. On wood surfaces, Dursban, Baygon, bromophos, and Hercules 9485 were still giving greater than 90 percent mortality at the termination of tests. In tests with free-flying mosquitoes and a 2-hour exposure, Dursban, bromophos, and Baygon gave more than 18 weeks of kills above 90 percent. Carbamult, Landrin and Mobam gave comparable results with a 4-hour exposure. EPN, GC–9879 and SD–8280 were ineffective when first tested. Caged mosquitoes suspended near the center of the hut for 2 hours showed complete kills for the duration of the tests with Dursban and Baygon deposits. Hercules 9485, Landrin, and Carbamult gave 97 to 100 percent kills for 11 to 14 weeks. SD–8280, GC–9879, Mobam and EPN gave low kills.

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